

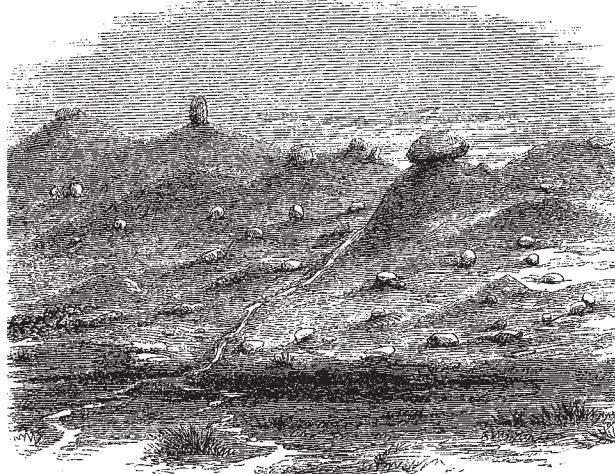
coral, and the position of the bank in lat. $36^{\circ} 29' N.$, long. $11^{\circ} 33' W.$ In other words, Commander Gorringe, on his journey westward from the Strait, after passing over the northern extremity of the deep channel, sounded up the steep slope of the submarine plateau which connects Portugal with Madeira, and within a short distance of a sounding of 1,525 fathoms obtained by H.M.S. *Challenger* on January 30, 1873, in lat. $36^{\circ} 23' N.$, long. $11^{\circ} 18' W.$

The sketch-map does not pretend to be more than an approximation founded upon the still limited number of soundings obtained up to this date, but the bottom-temperatures observed in this part of the North Atlantic tend to corroborate the views which I have ventured to express. They show that the submarine flow of cold water of antarctic origin, which has been traced as far north as the Bay of Biscay, also fills up the lower depths of the channel which stretches up towards Cape St. Vincent. On the other hand, the channel between the coast of Portugal and the Gettysburg Bank is occupied by the warm water of the Gulf Stream return-current, which, spreading itself out over the banks to westward, explains the presence of the live coral found by Commander Gorringe.

JOHN JAMES WILD

HUMMOCKY MORAINE DRIFT

DURING his survey of the West Pacific slopes, Clarence King found and has since described, hummocks of moraine drift on the "dying-out glaciers," which are somewhat similar to the "hog-wallows;" and J. le Conte has described dying-out glaciers and moraine drifts of California. Abstracts of these descriptions will be found in the *American Journal of Science and Arts*, and the full description of the West Pacific



Perched Erratic Blocks on Croagh-na-Cloosh.

slopes in Clarence King's report. In West Galway, Ireland, there are in places large tracts of drift sometimes like Clarence King's description, in others like the "hog-wallow;" that in the Memoirs of the Irish branch of the Geological Survey have been described as "rocky moraine drift." The accompanying sketch is of some of these drift hummocks on the north slope of Croagh-na-Cloosh, south of Oughterard.

G. H. KINAHAN

CONTRACTION OF THE LEAF OF "DIONÆA MUSCIPULA"¹

IN the first section of this paper the authors give an account of the mechanical effects which ensue on exciting the sensitive hairs of the Dionaea leaf. The following is a résumé of the principal conclusions at which the authors have arrived:—

¹ Abstract of paper on the Mechanical Effects and on the Electrical Disturbance consequent on Excitation of the leaf of *Dionaea muscipula*, by J.

If the sensitive hair of a vigorous leaf be touched with very great care by a camel-hair pencil, no visible effect on the leaf will be produced, and a similar gentle contact can be repeated several times before the leaf begins to answer to the excitation by any movement. Sooner or later, however, the marginal hairs bend inwards and the lobes slightly approach each other. The first actual excitation is followed by an almost imperceptible movement; after this each successive approach of the lobes in nearly every case exceeds that of its predecessor. The interval which elapses between excitation and effect diminishes as the extent of the effect increases, both facts having the same meaning, namely that in the plant, as in certain cases well known to the animal physiologist, inadequate excitations, when repeated, exercise their influence by what has been termed "summation," and thus the last contraction, that by which the leaf closes, is the result of the summation of the excitation which immediately preceded it with all the previous excitations. After the leaf has closed it still contracts at each excitation, and attempts to cleave itself with greater and greater force. The interval between an excitation and the resulting movement varies from two to ten seconds.

The authors next proceed to a consideration of the electrical condition of the leaf in an unexcited state, which has recently been made the subject of a minute investigation² by Prof. Munk, of Berlin, who has found—1. That if we conceive the external surface of the leaf divided into strips by parallel lines crossing the midrib nearly at right angles, and coinciding with the veining, any point of the external surface of each strip is negative to any point nearer the midrib. 2. That in comparing different points of the midrib with each other, there is one whose position is two-thirds of the distance from the near to the far end of the midrib, which is positive to the rest. 3. He has further stated that the potential of any point on the internal surface of the lobe is exactly equal to that of the corresponding and opposite point on the external surface. Of these three proportions the first two are confirmed, in the main, by the authors of the present paper; as regards normal leaves, however, they take exception to his conclusions on the two under-mentioned points—(a) That although there is a spot of greatest positivity on the midrib, more or less corresponding in position to that mentioned by Prof. Munk, yet its position is by no means so definite as Prof. Munk states, but varies in different leaves. (b) That the different points in his iso-electrical negative line are never found to be absolutely identical. From the third proposition the authors generally express their dissent. They, however, content themselves for the present with stating two general conclusions—1. That the part of the midrib which lies nearest the two central sensitive hairs is positive to every other part of the external surface of the leaf, but has usually the same potential as the petiole and other inactive parts of the plant. 2. That the external surface, so long as the leaf is in vigour, is always positive to the internal surface.

The method used in this research differs from that generally employed in previous investigations, relating to animal or plant electricity, in two important particulars:—1. In the adoption of Lippmann's electrometer³ (which has already been used by Prof. Marey in investigations on animal electricity) as the instrument for observing the electrical changes. 2. In the substitution of a constant for a variable potential as a standard of comparison with the potential under investigation.

In comparing the potentials of two points the following arrangement was usually adopted:—The pot containing the plant³ had been previously kept plunged in water. Three non-polarisable electrodes were used, by one of them (the "fixed electrode") the damp surface of the pot is connected with the gas-pipes of the building, the other two ("movable electrodes") are in contact with the two points under observation. By means of a switch, either of these two movable electrodes can be brought into connection with one end of the electrometer, the other end being connected with earth.

When the whole of the outer surface of a leaf is covered with a mass of kaolin, moistened with salt-solution, and brought into connection with one end of the electrometer, the other end being connected by means of the fixed electrode with the petiole or pot, the effect of exciting a sensitive hair is to produce an

Burdon-Sanderson, M.D., F.R.S., Professor of Physiology in University College, and F. J. M. Page, B.Sc., F.C.S. Read before the Royal Society, December 14, 1876.

² Reichert's and du Bois-Reymond's Archiv, 1876.

³ See the original paper, or Lippman, *Pogg. Ann.*, 1873, **149**, 546.

³ Most of the observations were made at Kew in the month of August, 1876, the plants being obtained from the Royal Gardens, through the kindness of the Director.

"excursion" indicating a change of potential *in a negative direction* at the movable contact amounting to 3·5 to 5·0 d ($d = \frac{1}{100}$ De La Rue element).

If a similar plug is applied to the internal surface, so as to cover the whole of it, the result is the same, but the extent of the excursion is somewhat less. Hence it may be generally stated that during the electrical disturbance *the surface of the leaf becomes more negative¹ as compared with any other surface of which the potential is constant*, and that on the external surface the change is greater than on the internal. This electrical disturbance is limited to the leaf and ceases at the point dividing the petiole from the isthmus or bridge, by which it is united with the leaf; on the petiole side of this point no sign of electrical disturbance is shown by the electrometer.

For various reasons the authors determined to direct their attention to the middle third of the leaf. The following were selected as representative points of contact:—(1) a point (*i*l) on the internal surface of the leaf equidistant from the three sensitive hairs; (2) a point on the external surface (*e*l) exactly opposite to *i*l; (3) and (4) points on the internal (*i*m) and external (*e*m) surfaces of the midrib, where the line joining the points *i*l on either lobe cuts the midrib; (5) the petiole (*p*); and (6) the bridge or isthmus (*b*) already mentioned. The letter P denotes the potential at any point, and V the variation of the potential during the electrical disturbance.

In four leaves the potentials and variations of the external surfaces of the midrib and lobe were severally in hundredths of a De La Rue cell:—

<i>e</i> m P as compared with <i>p</i> P ...	0	0	0	0
<i>e</i> l P	<i>p</i> P	16	0	16
<i>e</i> m V	-5·0	-6·5
<i>e</i> l V	-2·0	-6·5

The external variation is usually greater than the internal of a corresponding point, and the variation at *e*m is usually greater than that at any other point; thus in six leaves—

$$\begin{aligned} e l V &= -3\cdot6 \quad -4\cdot0 \quad -4\cdot2 \quad -4\cdot0 \quad -4\cdot0 \quad -4\cdot5 \\ i l V &= -1\cdot5 \quad -1\cdot7 \quad -1\cdot6 \quad -1\cdot8 \quad -2\cdot2 \quad -2\cdot2 \end{aligned}$$

and

$$\begin{aligned} i m V &= -3\cdot0 \quad -3\cdot5 \\ e m V &= -5\cdot5 \end{aligned}$$

When a leaf is excited at intervals of a minute or oftener by single shocks from a du Bois-Reymond's induction coil,² which are of just sufficient intensity to produce a response, it invariably happens that after a time the electrical variation ceases. The variation can be reproduced either by (1) shifting the needle-points to a fresh spot, (2) by increasing the strength of the induction-current, or (3) by allowing the leaf to rest for a longer interval. With relation to electrical stimuli, it is shown that the excitability of the leaf resembles that of the terminal organs of the higher animals, in this respect, viz., that relatively feeble stimuli, if applied at very short intervals and repeatedly, are competent to elicit a response.

If a leaf be excited at short intervals by faradisation, the excitations (makes and breaks) being continued each time until an excursion is produced, the combined effects of summation and gradually increasing exhaustion can be readily observed. At first the leaf responds after eight to ten excitations, but gradually the number of excitations required to awaken the tissues to action increases, the effect being postponed for longer and longer periods, until it finally fails to occur. When a leaf is excited at regular intervals by single shocks of such intensity as to be just beyond the limit of adequacy, the effects sometimes become rhythmical.

The time which intervenes between an excitation and the beginning of the electrical disturbance varies in different leaves, and is very much affected by variations of temperature. This time the authors have called the *period of electrical delay*.

As a mean of many experiments it was found that when the fixed electrode was on the petiole and the movable electrode on *e*m, the *delay* was 0·295 second. If the movable electrode was at *e*l or *i*l, the delay varied according to the proximity of the sensitive hair touched to the point of application of the movable electrode. Thus if the movable electrode was at *e*l and a

¹ It is interesting to note that the surface of a frog muscle, during the electrical disturbance which precedes contraction, becomes *positive*.

² Two steel needles sheathed in glass, and bound together, were used as exciting electrodes, the points of the needles being thrust through the epidermis of the leaf.

sensitive hair on the same lobe was touched, the delay was 0·231 sec.; but if a hair on the opposite lobe was touched the delay was 0·403 sec, the disturbance having to make its way from the sensitive hair on the opposite lobe through and across the midrib and up to the electrode. It is obvious that by measuring the distance between the hair touched and the electrode we can ascertain, more or less exactly, the rate of the transmission of what may be called the "wave of negative variation" through the leaf. From many experiments, the stimulation being sometimes mechanical and sometimes electrical, it was found that the wave traversed a distance of about 8 mm. in 0·18 sec., or at a rate of about 4·4 centims. per second. When the *period of delay* at *e*l was compared with that at *i*l, it was found that it was shorter at *e*l than *i*l; e.g., in some experiments (the excitation being weak faradisation and the excursions being taken from *e*l and *i*l alternately), the following numbers were obtained:—

Inside ...	0·71	0·61	0·68	0·75	0·95 sec.
Outside ...	0·48	0·50	0·52	0·65	0·49 ,

Finally, if either *e*l, *i*l, *e*m, or *i*m be compared with the bridge *b*, it will be found that the *period of delay* at *b* will be much greater than that at any of the other points;

thus <i>e</i> l	0·26	0·24	0·12	0·18 sec.
bridge (<i>b</i>)	0·87	0·65	0·85	0·83 ,

In normally active leaves, in which the disturbance is first seen about a sixth of a second after mechanical stimulation, the excursion attains its maximum in about one second, and the whole disturbance is over in about two seconds after the excitation, so that the electrical disturbance is entirely over before the mechanical effect begins, and consequently occurs in a period which in muscle is called the *period of latent stimulation*.

All these periods are, however, very much modified by temperature, being shortened if the temperature is raised (within certain limits), and lengthened if the temperature falls.

The following is one of several tables given in the paper, illustrating the effect of temperature on the periods of delay, maximum and total duration of the electrical disturbance:—

	In leaf at ordinary tempera- ture.	In warm chamber at 45° C.	Cooled by proximity of a block of ice.
Time in seconds after excitation.			
To beginning of excursion	0·23	0·11	0·44
To maximum	1·46	0·79	1·68
To end	2·2	1·37	2·94

THE SPONTANEOUS GENERATION QUESTION¹

AT the meeting of the French Academy of Sciences on January 29, M. Pasteur read the following reply to Dr. Bastian:—

Dr. Bastian, in reply to the communication which I made on January 8, along with M. Joubert, addressed to the Academy last Monday a long note, in which he still contrives, I think, to elude the main point of the debate. In our communication of January 8 there was one word of prime significance, *pure potash*; but, what is surprising, in the reply of three pages of Dr. Bastian there is not even allusion made to that condition of purity, which was everything.

I shall make a new attempt to recall the English *savant* to the criterion, from which he cannot escape, do what he will.

The discussion was raised by his statement, that a solution of boiled potash caused bacteria to appear in sterile urine at 50°, after it had been added to the latter in quantity sufficient for exact neutralisation. Dr. Bastian concluded that he had thus discovered the physico-chemical conditions of the spontaneous generation of certain bacteria.

This is my reply to the learned London professor of pathological anatomy:—

I defy Dr. Bastian to obtain, in presence of competent judges, the result to which I have referred, with sterile urine, on the sole condition that the solution of potash which he employs be pure, i.e. made with pure water and pure potash, both free from organic

¹ Continued from p. 314.